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IAP20 Rec'd PCT/PTO 22 DEC 2005

REMARKS

Applicants have made the foregoing amendments to place the PCT application text in customary US format with standard headings, so that all the claims can be considered on their merits. All multiple dependencies have been cancelled. Further explanation, of the EPILAM term mentioned in the specification, is included in the Information Disclosure Statement filed herewith. The Examiner is reminded that, pursuant to MPEP section 608.01(m), reference numerals are permitted in the claims, but are to be construed as having **no effect** on the scope of the claims.

If the Patent Office notes any remaining informalities which would prevent or hinder examination on the merits, a telephone call to counsel is requested.

Respectfully submitted,

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Att. Docket No. 870-3-200

Enclosures:
Substitute specification pages 1-4 & "clean" copies
Substitute amended text of claims 1-45

/MMO/AMEND/8703-200.PAM

10/562628

IAP20 Rec'd PCT/PTO 22 DEC 2005

MINI FAN

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CROSS-REFERENCE: This application is a section 371 of PCT/EP2004/005017, filed 11 MAY 2004, claiming priority from German applications DE 203 11 207, filed 16 JUL. 2003 and DE 20 2004 005 341, filed 30 MAR. 2004, the disclosures of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The invention relates to a mini-fan. Such fans are also referred to as miniature or subminiature fans.

BACKGROUND

Mini-fans serve, for example, to cool processors in computers, for the cooling of small equipment items, etc. and have very small dimensions. For example:

- fans of the ebm-papst 250 series have dimensions of 8 x 25 x 25 mm;
- those of the ebm-papst 400F series, dimensions of 10 x 40 x 40 mm;
- those of the ebm-papst 400 series, 20 x 40 x 40 mm; and
- those of the ebm-papst 600 series, 25 x 60 x 60 mm.

The power consumption of such fans is 0.4-0.6W for the 250 series, 0.7-0.9 W for the 400F series, and 0.9-3.4 W for the 400 and 600 series. The weight is, for example, approximately 5 (five) grams for the 250 series, between 17 and 27 g for the 400/400F series, and approximately 85 g for the 600 series.

With fans of this miniature size, which must be very inexpensive, it is important to make assembly as simple as possible in order to enable a high level of automation during manufacture. Only extensive production automation additionally makes possible uniform quality in such fans, which is a prerequisite for a long average service life.

A complicating factor with such mini-fans is furthermore that their components, entirely comparable to those of a mechanical watch mechanism, are very delicate and therefore not robust. The rotor shaft, for example, is often only as thick as a knitting needle, and can therefore easily be bent if handled carelessly, rendering the fan unusable. This danger exists in particular during the assembly of such a mini-fan, for example when it must be acted upon by a force for assembly purposes.

SUMMARY OF THE INVENTION

An object of the invention is therefore to make available a novel mini-fan. According to the invention, this object is achieved by ~~the subject matter of Claim 1.~~ configuring the fan motor with an internal stator and external rotor, the rotor being rotatably supported in a bearing tube equipped with a closure arrangement which closes off one end of the bearing tube in a liquid-tight manner, and includes at least one resilient securing member to engage into a necked down portion of the rotor shaft and thereby keep the rotor shaft from being pulled out of the bearing.

What is thereby achieved, with simple means, is a secure, liquid-tight join between the bearing tube and the closure arrangement. Because the invention makes it possible to assemble the internal stator while it is still separate from the rotor, and because the internal stator is a substantially more robust component than the external rotor, the danger of damage during the assembly operation is substantially reduced.
In the context of a mini-fan according to the present invention, it is therefore possible first to assemble the internal stator; and once the latter has been, for example, soldered in place on a circuit board, the rotor can then very easily be installed and at the same time secured, by way of the at least one resilient securing member, against being inadvertently pulled out.

Further details and advantageous refinements of the invention are evident from the exemplifying embodiments, in no way to be understood as a limitation of the invention, that are described below and depicted in the drawings. ~~, and from the additional claims. In the drawings.~~

BRIEF FIGURE DESCRIPTION

FIG. 1 is a greatly enlarged longitudinal section through a mini-fan according to a preferred embodiment of the invention; for illustration only, a one-centimeter length is indicated for comparison, although the size of the fan can of course fall within the limits typical for such miniature and subminiature fans;

FIG. 2 is an even greater enlargement to explain the lubricant circulation in the bearing arrangement with plain bearing that is depicted;

FIG. 3 depicts one possible variant for connecting the stator winding of the external-rotor motor according to FIGS. 1 and 2 to a circuit board;

FIG. 4 is a very greatly enlarged longitudinal section through a mini-fan according a second embodiment of the invention;

FIG. 5 shows a portion of FIG. 4 at location V therein;

FIG. 6 is a section according to a first alternative, looking along line VI-VI of FIG. 4;

FIG. 7 is a section according to a second alternative, looking along line VI-VI of FIG. 4;

FIG. 8 is a section analogous to FIG. 4, but after the mating of the internal stator and circuit board;

FIG. 9 is a depiction analogous to FIG. 8, but before the mating of the internal stator and external rotor; and

FIG. 10 is a depiction analogous to FIG. 9, but after the mating of the internal stator and external rotor; the external rotor is secured on the internal stator against being pulled out, and the lower (in FIG. 10) side of the bearing support tube is closed off in liquid-tight fashion.

DETAILED DESCRIPTION

FIG. 1 shows, at very greatly enlarged scale, a longitudinal section through a mini-fan 16 associated with which, for driving thereof, is an external-rotor motor 20. Fan 16 can have, for example, dimensions of 10 x 30 x 30 mm. Motor 20 has an external rotor 22 having a rotor cup 24, preferably made of a thermally conductive plastic, on whose outer periphery fan blades 26 are provided. A magnetic yoke 27 made of soft iron is mounted in rotor cup 24, and on the yoke's inner side is a radially magnetized rotor magnet 28 that can be magnetized, for example, with four poles. The outside diameter of external rotor 22 can range, for example, from approximately 14 to approximately 35 mm.

Fan 16 is depicted here as an axial fan, but the invention is equally applicable, for example, to diagonal fans and to radial fans.

Rotor cup 24 has at its center a hub 30 in which is mounted, in thermally conductive fashion by plastic injection molding, a correspondingly shaped upper shaft end 32 of a rotor shaft 34 whose lower, free end is labeled 35.

Radial support of shaft 34 is provided by a plain bearing 36 that preferably is implemented as a sintered bearing. Alternatively in the context of the invention, in order to achieve a particularly long service life, shaft 34 can also be supported using rolling bearings. Plain bearing 36 is mounted by being pressed into the interior of a constriction 37 of a bearing tube 38. Bearing tube 38 is preferably manufactured from steel, brass, or another suitable metal, or if applicable also from a plastic. Provided at its lower end is a radial projection in the form of a flange 39, which serves for the mounting of fan 16 and here extends approximately perpendicular to rotation axis 41 of rotor 22. Internal stator 44 of motor 20 is mounted on the outer side of bearing tube 38 by being pressed on.

Constriction 37 has a substantially cylindrical inner side 40 (FIGS. 2 and 3) whose surface is particularly carefully machined, while the remainder of the inner side of bearing tube 38 needs to be only roughly machined. Corresponding to constriction 37, sintered bearing 36 has a bulging portion 42 having a diameter that corresponds approximately to the diameter of inner side 40 and is dimensioned so that a tight fit results upon assembly in inner side 40. Within portion 42, sintered bearing 36 has a portion 43 (FIG. 2) having an enlarged diameter, at which the sintered bearing does not make contact against shaft 34. This prevents sintered bearing 36 from being excessively radially compressed in the event of an accumulation of unfavorable tolerances, which might make it impossible to insert shaft 34.

A lower plain bearing portion 48 is located below portion 43, and an upper plain bearing portion 50 is located above portion 43 (cf. FIG. 2). It has been found that specifically in mini-fans with their small dimensions, very reliable support of shaft 34, and a correspondingly long service life for motor 20, are thereby obtained.

~~CLAIMS~~ WHAT IS CLAIMED IS:

1. (Currently Amended) A mini-fan that comprises:

a drive motor having an external rotor (222) and an internal stator (244), which external rotor is equipped with a rotor shaft (234) that is equipped with a necked down portion (258) adjacent its free end (235);

a bearing tube (238) on whose outer side the internal stator (244) is mounted, and in whose interior is arranged a bearing arrangement (236) in which the rotor shaft (234) is rotatably supported;

a closure arrangement (62; 262) that closes off the bearing tube (238) in liquid-tight fashion at one end, and is equipped adjacent the necked down portion (258) of the rotor shaft (234) with at least one resilient securing member (260) that engages into that necked down portion (258) of the rotor shaft (234) and secures the rotor shaft (234) against being pulled out of the bearing arrangement (236).

2. (Currently Amended) The mini-fan according to claim 1, wherein

the closure arrangement is implemented [in the manner of] as a cover (62) that is made from a thermoplastic that is at least partially transparent to laser light, that cover (62) being attached by means of a substantially liquid-tight welded join (100, 102).

3. (Currently Amended) The mini-fan according to claim 2 which comprises

a housing having a flange (78); and wherein

the welded join (100, 102) is provided at a location at which the cover (62) at least partly overlaps a portion of that flange (78).

4. (Currently Amended) The mini-fan according to claim 2 ~~or 3~~, which further comprises

a housing having a flange (78), wherein

the bearing tube (38) is held between the closure arrangement implemented [in the manner of] as a cover (62) and a portion of that flange (78).

5. (Currently Amended) The mini-fan according to claim 2, ~~any of claims 2 to 4,~~ wherein

the bearing tube (38) is pressed in substantially liquid-tight fashion into an opening (80) ~~of~~ formed in the flange (78).

6. (Currently Amended) The mini-fan according to claim 5, wherein

the bearing tube (38) ~~is implemented as a~~ consists essentially of metal ~~part~~, and is epilam-coated on its side that is pressed into the flange opening (80).

7. (Currently Amended) The mini-fan according to claim 3, ~~any of claims 3 to 6,~~ wherein

the bearing tube (38) is equipped with a radial projection (82) that is held in positively engaged fashion between the closure arrangement (62) ~~implemented in the manner of a cover~~ and a portion of the flange (78).

8. (Currently Amended) The mini-fan according to claim 7, wherein the radial projection is implemented ~~in the manner of~~ as a flange (82).

9. (Original) The mini-fan according to claim 8, wherein the flange (82) is provided on an end portion of the bearing tube (38).

10. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~ wherein the rotor shaft (34; 234) comprises

a free end (35; 235), facing away from the rotor (22; 222), on which a tracking cap (68; 268) is formed for axial support;

and wherein a support surface (66; 266) for that tracking cap is provided on the closure arrangement (62; 262).

11. (Original) The mini-fan according to claim 10, wherein

the support surface is implemented as a depression (66; 266) and is equipped with a lubricant (110).

12. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~

wherein the at least one resilient securing member (60; 260) protrudes into the necked down portion (58; 258) of the rotor shaft (34; 234) without touching it.

13. (Original) The mini-fan according to claim 12, wherein

there is provided, adjacent the free end of the shaft (34; 234), a spreading member (35; 235) that is implemented to deflect the at least one resilient securing member (60; 260) in a radial direction upon installation of the shaft (34; 234).

14. (Currently Amended) The mini-fan according to claim 10, ~~any of claims 10 to 13,~~ wherein

the tracking cap (68; 268) is acted upon by a magnetically generated force ~~(Fm)~~ urging said rotor shaft in ~~the~~ a direction toward the closure arrangement (62; 262).

15. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~ wherein

the closure arrangement is implemented ~~in the manner of~~ as a plug ~~(262)~~ that is mounted in an opening ~~(271)~~ of the bearing tube ~~(238)~~.

16. (Currently Amended) The mini-fan according to claim 15, wherein

the closure arrangement ~~(262) implemented in the manner of a plug~~ is pressed in liquid-tight fashion into the opening of the bearing tube (238).

17. (Currently Amended) The mini-fan according to claim 15 ~~or 16~~, wherein

at ~~the~~ a transition point (271, 283) between the bearing tube (238) and plug (262), there is implemented on one of those parts an annular ridge (284, 285) and on the other part an annular groove (272, 273) complementary thereto, which together form a latching connection when the plug (262) is installed.

18. (Currently Amended) The mini-fan according to claim 15, ~~any of claims 15 to 17,~~ wherein

the bearing tube (238) has a larger inside diameter at its portion (271) provided for reception of the plug (262) than at its portion (240) provided for reception of the bearing arrangement (236).

19. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~ wherein

the bearing tube (238) comprises a portion (278) that protrudes away from the rotor (222) and is implemented for installation in an opening (280) of a component (217).

20. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~ wherein the internal stator (44; 244) comprises a lamination stack (45; 245) on which is arranged a coil former (46; 246) having a stator winding (247), and mounted on that coil former is at least one rigid electrical conductor (132; 288) that is electrically connected to the stator winding (247) and ~~preferably~~ extends substantially parallel to the rotation axis (41; 241) of the mini-fan.

21. (Original) The mini-fan according to claim 20,

wherein the bearing tube (238) comprises an outwardly protruding flange (239) that is equipped with an orifice (292) for the passage of the rigid electrical conductor (288).

22. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~

wherein the internal stator (44; 244) comprises a lamination stack (45; 245) and the external rotor (22; 222) comprises a permanent magnet (28; 228) coacting with the internal stator, which magnet is offset relative to the lamination stack (45; 245) of the internal stator (44; 244) in such a way that a magnetic force ~~(Pm)~~ is generated which acts upon the tracking cap (68; 268) in ~~the~~ a direction toward the support surface (66; 266).

23. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~

wherein an end portion (32; 232) of the shaft (34; 234) is joined to a fan wheel (26; 226);

and ~~in the region of the~~ near a transition from the shaft (34; 234) to the fan wheel (26; 226); a surface (112; 312) is provided which extends approximately radially and is located inside the bearing tube (38; 238), so that lubricant (110) thrown off from that surface upon rotation of the fan wheel is thrown into the interior of the bearing tube (38; 238).

24. (Original) The mini-fan according to claim 23, wherein the approximately radially extending surface (112; 312) is implemented in undercut fashion.

25. (Currently Amended) The mini-fan according to claim 23 ~~or 24~~,

wherein the bearing tube (38; 238) comprises, in the region of its end facing away from the cover (62; 262), an inwardly protruding portion (114; 314).

26. (Currently Amended) The mini-fan according to claim 25,

wherein the inwardly protruding portion (114; 314) is separated from the fan wheel (26; 226) at least locally by a gap (116; 316) that is implemented in the manner of a capillary gap, in order to reduce the emergence of lubricant (110) through that gap.

27. (Currently Amended) The mini-fan according to claim 25 ~~or 26~~,

wherein the inwardly protruding portion is implemented, on its side facing toward the closure arrangement (62; 262), in the manner of an undercut (114; 314).

28. (Currently Amended) The mini-fan according to claim 1, ~~any of the preceding claims,~~

wherein a sintered bearing (36; 236) is provided in order to support the shaft (34; 234), which bearing is arranged in the bearing tube (38; 238) that ~~preferably~~ comprises on its inner side a portion (138) of reduced diameter, for reception of the sintered bearing (36; 236).

29. (Original) A mini-fan having a housing (74) that is equipped with a flange portion (78) that in turn comprises a flange opening (80),

having a cover (62) for closing off that flange opening (80),

further having a join (100, 102) provided between the flange portion (78) and the cover (62),

and having a bearing tube (38) in which a bearing arrangement (36) for a shaft (34) of the fan is located;

the bearing tube (38) being held in positively engaged fashion between the cover (62) and flange portion (78).

30. (Original) The mini-fan according to claim 29,

wherein the bearing tube (38) is pressed in substantially liquid-tight fashion into the flange opening (80).

31. (Currently Amended) The mini-fan according to claim 29, ~~any of claims 28 to 31,~~

wherein the bearing tube (38) is equipped with a flange (39) that is held in positively engaged fashion between the cover (62) and the flange portion (78).

32. (Currently Amended) The mini-fan according to claim 29, ~~any of claims 28 to 31,~~

wherein the join between the flange portion (78) and cover (62) is implemented as a welded join (100, 102).

33. (Currently Amended) The mini-fan according to claim 29, ~~any of claims 28 to 32,~~

wherein the shaft (34) of the fan comprises a free end (35);

and a holding apparatus (60) that is implemented to retain that free end (35) is provided on the cover (62).

34. (Currently Amended) The mini-fan according to claim 29, ~~any of claims 28 to 33,~~ wherein

the shaft (34) of the fan has a free end (35) that is equipped with a tracking cap (68) associated with which is a corresponding depression (66) in the cover (62), which depression forms, together with the tracking cap (68), a bearing for the shaft (34).

35. (Currently Amended) The mini-fan according to claim 5, ~~any of claims 5 to 34,~~

wherein the bearing tube (38) ~~comprises~~ is formed with a constriction (37) in which a sintered bearing (36) is mounted.

36. (Original) The mini-fan according to claim 35, wherein the inner side (40) of the constriction (37) has a better-machined surface than other, unconstricted portions of the inner side of the bearing tube (38).

37. (Original) A mini-fan, having a fan wheel (22) that is equipped with a shaft (34) for support thereof,

having a sintered bearing (36) to support that shaft (34),

having a bearing tube (38) for reception and retention of the sintered bearing (36), which bearing tube comprises, on its inner side, a portion (37) having a reduced inside diameter, in which portion the sintered bearing (36) is mounted.

38. (Original) The mini-fan according to claim 37,

wherein the sintered bearing (36) comprises a portion (42) having an enlarged outside diameter, which outside diameter corresponds approximately to the reduced inside diameter of the bearing tube (38) in order to permit mounting of the sintered bearing (36) in the bearing tube (38) in the region of that portion (42) having an enlarged outside diameter.

39. (Currently Amended) The mini-fan according to claim 37 ~~or 38~~,

wherein the bearing surfaces (48, 50) of the sintered bearing (36) are located substantially outside the portion (42) having an enlarged inside diameter.

40. (Currently Amended) The mini-fan according to claim 37, ~~any of claims 37 to 39,~~

wherein the bearing surfaces (48, 50) of the sintered bearing (36) are located substantially at locations that are located outside the locations at which the sintered bearing (36) is held in the bearing tube (38).

41. (Currently Amended) The mini-fan according to claim 37, ~~any of claims 37 to 40,~~

wherein the shaft (34) comprises a free end (35) facing away from the fan wheel (22),

and ~~in the region of~~ near this free end (35), at least one closure member (62) is provided which seals that end (39) of the bearing tube (38) in substantially liquid-tight fashion.

42. (Original) The mini-fan according to claim 41,

wherein a lubricant supply (64) is provided in the region of the sealed end (39) of the bearing tube (38).

43. (Currently Amended) The mini-fan according to claim 41 ~~or 42~~,

wherein the shaft (34) is equipped in the region of its free end (35) with a tracking cap (68), associated with which in the closure member (62) is a corresponding running surface (66) that, together with the tracking cap (68), forms an axial bearing for the shaft (34).

44. (Currently Amended) The mini-fan according to claim 37, ~~any of the preceding claims,~~

wherein the shaft (34) comprises a free end (35) facing away from the fan wheel (22),

and in the region of that free end (35) an annular groove (58) is provided into which protrudes, in the assembled state, a resilient latching member (60) that is mechanically connected to the housing of the mini-fan and counteracts pulling of the installed shaft (34) out of the sintered bearing (36).

45. (Original) The mini-fan according to claim 44,

wherein the resilient latching member (60) is implemented integrally with a closure member (62) which serves to close off the bearing tube (38) in substantially liquid-tight fashion.